Responses to the HENEX 65% Design Review Comments/Questions Compiled by John Seely

The 65% Design Review Comments/Questions were emailed to NRL on May 4, 2001. A response is provided after each comment/question.

Comment/Question Impact Types:
1=If left unresolved, could result in a recommendation of "rejection of a specific aspect of design."
2=If left unresolved, could result in a recommendation of "acceptance of the design with comment."
3=Comments that provide information and suggestions to the design team.

Pages refer to the 65% Design Review presentation at the website
http://spectroscopy.nrl.navy.mil/HENEX/Reviews/65%25DR/65%25DR.html

A. Carl Pawley

A.1. (Type 2, Software) Work out the details of software ownership. Allow sufficient flexibility to allow rebuilds to another standard if LLNL requires it.

John Seely: Rob Atkin and Tiger Innovations Inc. (TI) are committed to supporting the HENEX software and making modifications to accommodate possible future changes. If for some unforeseen reason TI is unable to do this, TI has offered to place the software in escrow at NRL. The original NIF specifications and requirements did not address the disposition of the source code, and the HENEX budget and the agreement with TI does not cover the cost of providing the source code. A possible option is for LLNL to purchase the source code.

A.2. (Type 2, Debris) Clearly define the closest position the end of the snout will have, and insure it stays clear of all hazards. Be able to realign instrument to use snouts as far away as 2 M from center

Glenn Holland: When HENEX is deployed at the 2.2 m standoff distance (2.2 m is the target to crystal distance), the end of the snout will be outside the 0.5 m NIF exclusion zone. The nosecone will be inside the 10^{o} included cone angle allowed for NIF diagnostics. When deployed at the 2.2 m standoff distance, as recommended by NIF planners, the HENEX alignment will be accomplished with alignment telescopes supplied by NIF, and the alignment procedure will be developed and optimized by NIF operators. The plan is to have one of the alignment telescopes positioned opposite the HENEX DIM and viewing the end of the nosecone for alignment of the HENEX optical axis to TCC. It should be noted that on NIF first-light shots, HENEX can be deployed at the 0.5 m standoff distance (0.5 m will be the target to crystal distance used for early tests at LLE). In this case, alignment can be accomplished with the removable pointer implemented for LLE deployment or with the NIF-provided telescopes. With the pointer removed, the end of the snout would be 17.8 cm from TCC. Although this would be within the 0.5 m NIF standoff distance, NIF planners might consider waiving this requirement on low energy first-light shots. Alternately, HENEX can be deployed at 2.2 m on first-light shots.

A.3. (Type 2, DIM Ports) Which Dim ports are being allocated for the HENEX? Need to verify access. (just because there is a dim port there may not mean a dim be there)

Perry Bell: HENEX is designed to be DIM compatible, and this allows it to be configured in any DIM as necessary for experiments. We do not have any specific placement requirement at this time other than to be DIM compatible. This does raise the issue of time to configure the instrument for a given experiment. The instrument requires that the diagnostic controller be connected to the instrument's DIM. Additional time will be required to move the hardware to that DIM's location. There is a DIM deployment plan that was presented at the NIF PRC review and is available on the diagnostic website.

<u>B. Nino Landen</u>

B.1. (Type 2, Requirement) The stated sensitivity of 5e18 keV/keV was not a requirement but an extrapolation of Nova capability, and seems high: 5e18 keV/keV = 1 J/eV at 5 keV. Since instrument resolution (and line width) is ≈ 20 eV at 5 keV, this sensitivity corresponds to 20 J of line emission. For a 0.1% efficient source, this then translates to 20 kJ of laser energy, much greater than the minimum laser energy envisaged for sources such as short pulse backlighters. I recommend requirement of 0.01% of 1 kJ = 2e16 keV/keV at 5 keV. Since energy bandwidth scales with photon energy in instrument design, the more general requirement is to say 5e14 keV per spectral resolution element = 0.1 J of x-rays per spectral resolution element.

Tina Back: A clearer statement of the sensitivity requirement will be incorporated into the diagnostic requirements, to be reviewed by the diagnostic expert group. The completion of that action will be reported at the 100% design review.

B.2. (Type 3, Mechanical) Alignment tolerances and strategy, especially in terms of angular misalignment with and without aperture is important to address in 100% review

Glenn Holland: As described in A.2 above, the alignment will be accomplished with alignment telescopes supplied by NIF, and the alignment procedure will be developed and optimized by NIF operators. The accuracy of the HENEX alignment will depend on the accuracy and reproducibility of the DIM angular and axial motions and on the ability of the NIF operators to view the HENEX nosecone. The information from NIF indicates that the DIM X and Y pointing will be accurate to ±25 μm. Misalignment at this level would result in a movement of the spectrum on the sensor by a pixel, and this can be corrected using the absorption filter edges.

Perry Bell: In addition, HENEX will require alignment in a pre-alignment station at NIF to set the initial line-of-sight based on the droop of the DIM due to the weight of the instrument. If alignment by a pointer should be preferred by the NIF alignment group, the pointer would be metrologized to the diagnostic in this offline alignment system.

B.3. (Type 2, Requirement) There was no discussion on whether the instrument would meet the dynamic range and sensitivity requirements. This should be presented at 100% review. Presumably there is averaging in the non-spectral direction which increases dynamic range?

John Seely: The dynamic range specification, as listed on page 8 of the Opening Viewgraphs, is 100. This is easily met by the 12-bit digitization of the spectral image and the use of attenuation filters to insure that the spectrum is on scale. While the entire 2D spectral image is downloaded and saved, there is the ability to sum and average in the non-dispersion direction to improve the quality of the spectrum. The summing can be carried out over the regions of the sensor covered by various filter materials and thicknesses. The sensitivity depends primarily on the crystal and sensor performance. This will be the subject of early procurements and study (page 12 of the Interface/Sensor Viewgraphs), and the results will be reported at the 100% Design Review.

C. Faith Shimamoto

C.1. (Type 2, Electronics SW) Need to have Software Requirements Specification, Software Design Specification, Software Verification and Validation Plan (Acceptance Test Plan), User Manuals (Operations and Maintenance) as specified by the *JCDT Requirements and Recommendations for Target Diagnostic Development,* Section 4.0

John Seely: It is not possible to fully address this and many of the following comments until the NIF software protocols have been finalized. In the absence of specific and detailed NIF guidelines that are finalized and will not change in the future, the HENEX electronics are designed to have the flexibility to accommodate LLE protocols, and NIF protocols based on the limited information we presently have. The HENEX design team will work with Ms. Shimamoto and colleagues to resolve this and other issues before the 100% design review. The HENEX team will visit LLNL to expedite this process. The resolution of this and other issues will depend on the finalization of the NIF software and protocol specifications at the earliest possible date so that HENEX can be designed to meet those specifications.

C.2. (Type 2, Electronics SW) How is software configuration managed? When the software runs, is the current version number displayed and/or saved as part of the data set?

See C.1 response.

C.3. (Type 2, Electronics SW) Recommendations are provided for Processor, Operating System, Network File Interface, Programming Language, and bus architectures in the *JCDT Requirements and Recommendations for Target Diagnostic Development*.

Documentation of what was/is used, including versions should also be included in design documentation and maintenance manuals.

See C.1 response.

C.4. (Type 2, Electronics SW) Data Storage requirements should be defined. Storage should be in HDF format (*JCDT Requirements and Recommendations for Target Diagnostic Development*, Section 3.1.4). Provide documentation on what data is stored. Recommendations include setup, configuration calibration, background, shot, and control point data. Should add software version number.

See C.1 response.

C.5. (Type 2, Electronics SW Page 10) What are the plans for data processing (Quick-Look)? Reference *JCDT Requirements and Recommendations for Target Diagnostic Development, Section 3.1.6)*

John Seely: Quick look at the five spectral images will be provided immediately after download.

C.6. (Type 2, Electronics SW Page 3) Will this diagnostic operate in a classified environment. If so, what will the classified configuration look like? It appears to currently require local storage. Can it run without local storage?

Perry Bell: The design stand and guideline for classified operation are not complete at this time. The current design has no capability to gather and store classified data within the DIM. All HENEX data are transmitted via fiber optic. We are building in a "not to preclude mode", not knowing what the real requirements are.

C.7. (Type 2, Electronics SW Pages 5/6) How is the diagnostic configuration created, stored, and retrieved? Is there software for this? What is included in the configuration information? If there is a tool for creating the configuration file, what documentation is available for it?

See C.1 response.

C.8. (Type 3, Electronics SW Page 9) Are configuration parameters validated by the controller? i.e. set and read back?

See C.1 response.

C.9. (Type 2, Electronics SW) Is there a difference between a dry run and a real shot? Do you need to be able to tell the difference and how would you do that? Is there a source that needs to be controlled for a dry run?

See C.1 response.

C.10. (Type 2, Electronics SW Page 9) How does the controller respond to a Hold or Abort?

See C.1 response.

C.11. (Type 2, Electronics SW Page 9) Can the controller generate a Hold or Abort? What would be possible Hold or Abort conditions?

John Seely: The HENEX team will provide two documents that address this and some other issues: (1) A timeline showing the JCDT communication protocol and how the instrument is responding to the protocol. (2) A state diagram showing the software and hardware functions and processes the instrument is going through during countdown.

C.12. (Type 2, Electronics SW Page 9) It appears that data is "automatically" downloaded on shot completion. Where is it downloaded to? Local controller, DIU, DCP? Do you always want to download? What if there was an abort condition?

See C.1 response.

C.13. (Type 2, Electronics SW Page 9) Instrument timeline needs to show synchronization with the DCP protocol and where the processing is taking place. (assuming that you need to synchronize otherwise, explain how you know what's happening? Or how you would know if you are included in this shot? Or the shot number…etc.)

See C.11 response.

C.14. (Type 3, Electronics SW Page 4) The system can power down to a "sleep mode: to save battery. What conditions and/or triggers allow/cause a power down?

See C.1 response.

C.15. (Type 2, Electronics SW) Proprietary Hardware and Software license needs to be procured or needs to be put into escrow

See A.1 response.

C.16. (Type 2, Electronics SW) How is proprietary software managed for change request, update, OS changes? Is there a budget plan for these costs? A plan should be generated for documenting and managing change requests and changes/updates

See A.1 response.

<u>D. Dan Kalantar</u>

D.1. (Type 2, Opening Page 8, Mechanical) You have a spec on the field of view. Is there a spec on the range of alignment for this instrument? It needs to be pointable to within the DIM range to see targets up to 5 cm (ie where beams can point).

Glenn Holland: The HENEX diagnostic will be installed on the DIM cart with the HENEX optical axis coincident with to the DIM's center line. The HENEX instrument can then be pointed within the range of DIM angular motions. The information from NIF indicates that the DIM pointing range will be $\pm 2^{o}$ when mounted on a 20" port and $\pm 1^{o}$ when on an 18" port. The pivot point is a gimbal 620.025 cm from TCC resulting in pointing ranges of ±21.6 cm and ±10.8 cm at TCC.

D.2 (Type 2, Overview Page 3, Mechanical) The working distance is identified as 0.5 or 2.2 m. Is this a range or either 0.5 or 2.2? Also, if it can go in to 0.5 m, is this consistent with the statement later that it takes only 6'x1'x1' for storage? (sec 6, p 7) If it gets to within 0.5 m, then it must be 2.5 m in length. I think that the 0.5m length is for operation at LLE in a TIM

Glenn Holland: The standoff distance for the HENEX diagnostic will be either 0.5 m or 2.2 m from TCC, where 0.5 m or 2.2 m refers to the TCC to crystal distance. Owing to the off-axis positioning of the HENEX reflection crystal spectrometers in the DIM, these spectrometer boxes are tilted slightly inward by the appropriate angle to view the target at a given standoff distance. Two tilt settings and two HENEX nosecones will be provided to accommodate the lines of sight for the two standoff distances of 0.5 m and 2.2 m. Thus the standoff distance is not a range, but either 0.5 m or 2.2 m. The 0.5 m distance was chosen for the early tests at LLE, and 2.2 m was chosen because that was the HENWAY standoff at NOVA. As mentioned in A.2 above, it would be possible to deploy HENEX at the 0.5 m standoff on low energy first-light NIF shots if the 0.5 m exclusion zone requirement were waived. The 6'x1'x1' storage space will accommodate the HENEX diagnostic with the 0.5 m standoff nosecone (the LLE and NIF first-light configuration). The design of the HENEX nosecone for 2.2 m standoff is still under consideration and will be influenced by field of view and aperture considerations. It is likely that a longer storage space will be required for the HENEX instrument in the 2.2 m standoff configuration owing to the longer nosecone. If the nosecone extended to 0.5 m from TCC in the case of 2.2 m standoff deployment, then the total length of HENEX would be ~2.7 m, which is shorter than the 3 m maximum diagnostic length for a DIM.

D.3 (Type 2, Overview Page 11, Mechanical) There is a statement that the battery pressure vessel is over designed by at least a factor of 100.... this is not easy to understand without the details... and they are in Sec 4, p 9. However, on that page, I see a statement that the safety factor exceeds 4X normal pressure, and another that the factor of safety on the end-cap is only 28. I am not sure that this is all consistent. Also, the NIF TES area must have some spec on the requirement... what is it? If not, there needs to be one developed. This issue was discussed at length at the review.

Glenn Holland: The HENEX battery pressure vessel will be similar to the one built for the LLE Hard X-Ray Spectrometer (HXS) pictured on viewgraph 9. The safety factors quoted on viewgraph 9 resulted from the engineering analysis of the HXS battery pressure vessel. That pressure vessel was designed with safety factors greatly exceeding the normally accepted minimum safety factor of 4. The feature of the HXS pressure vessel with the smallest safety factor was the end cap with a safety factor of 28. Other safety factors were 115 or larger. In order to strengthen the HENEX pressure vessel, the welded end cap will be thickened, and the safety factor should exceed 100. The HENEX pressure vessel will be fabricated by MDC Vacuum Products Corporation. A recent inquiry to an MDC engineer indicated that MDC is not aware of the failure of this type of weld under normal vacuum cycling in the entire history of MDC.

D.4 (Type 2, Interface Page 7, Mechanical) The DIU and DCP require 4 feet of 19 inch rack space (4'x3'x19"). Is this typical? How are we going to work into the operations plan that this gets moved around as required to field an instrument in different DIMs on different shots? And is there even that much rack space available for the different DIMs?

Perry Bell: Will check with the NIF facility rep.

D.5 (Type 2, Interface Page 7, Electrical) Two x 20 Amp 110 VAC service for each instrument is a lot. Is this consistent with the plans for other instruments? What about with the service to each rack unit and cooling capabilities in the racks?

Perry Bell: The NIF baseline is 20 amps per 6' rack.

D.6 (Type 2, Interface Page 8, Mechanical) There is a statement that the instrument will be baked out and bagged before delivery. What is the plan re cleanliness in the diagnostics building? What about regarding transportation and use at calibration facilities? I am guessing that the common thought is we do not need to be so clean. Should this be a requirement on the HENEX team?

Perry Bell: Until we get a clear definition from NIF, we will use the cleanliness guideline for NIF diagnostics that is on the website.

D.7 (Type 2, Interface Page 9, Operations) There are a couple of specific tasks identified for an operations technician. Are all of these performed while the instrument is in the DIM (ie accessed from the front?). What about other things like replacing module or crystal between shots? The times listed appear to be incomplete since there are other activities to field the instrument... insert in the DIM, connect, pump, run-in. Most of these are going to be applicable for all instruments, but some of the inspection/access may not be. Is the right amount of time identified for all those that are not 'normal'? Include this as a comment but note that this area needs more coverage at the 65% review. I think that we should require that for future reviews there is a more detailed discussion of operations but I don't think that we should insist on that in this case.

Glenn Holland: The time estimates were based on the experience with the TIM-based Hard X-Ray Spectrometer at LLE. A clearer and more complete accounting of the HENEX operation times will become available as HENEX is built and tested.

D.8 (Type 2, Interface Page 10, Calibrations) It appears that nothing needs to be calibrated as a unit. Where are specific calibration requirements for components spelled out? And what are those requirements? It may be that we need calibration (pending funds is stated on sec 1, p 5)... and this is not obviously worked into the table in sec 6 p 10.

Larry Hudson: We have proposed an end-to-end absolute intensity calibration of each of the 5 channels of the HENEX instrument. Keep in mind that associated with each channel will be a unique set of filtration, crystal, detector window, phosphor converter layer thickness, CMOS sensor, and ADC card. A very different facility would have to be constructed to calibrate individual bent crystals or sensors in an absolute sense. Addition of this capability would be especially challenging for that portion of the 1 to 20 keV energy range that would require vacuum operation. It would be possible, however, to make relative sensitivity measurements of replacement bent crystals or detectors under standard conditions permitting interchange of these components without requiring a new end-to-end calibration. These backup crystals and detectors, if procured in advance, could be calibrated along with the HENEX instrument. Alternatively, a backup spectrometer channel could be constructed and a second electronics package procured so that these relative measurements could be performed at NIST even though the instrument were in the field. A third possibility notes that the calibration facility will eventually be entirely transferred to and handed off to LLNL for periodic intensity calibrations. At this point, it would be possible to interchange sensors or other HENEX components and make relative sensitivity comparisons using the HENEX instrument on-site at NIF. This would be the least costly option.